SI-TRACEABLE SCALE FOR MEASUREMENTS OF RADIOCARBON CONCENTRATION

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Radiocarbon (^{14}C) dating of organic materials is based on measuring the $^{14}C/^{12}C$ atomic fraction relative to the nascent value that existed when the material was formed by photosynthetic conversion of carbon dioxide present in the atmosphere. This field of measurement has numerous applications including source apportionment of anthropogenic and biogenic fuels and combustion emissions, carbon cycle dynamics, archaeology, and forensics.

Accelerator mass spectrometry (AMS) is the most widely used method for radiocarbon detection because it can measure extremely small amounts of radiocarbon (background of nominally 1.2 parts-per-trillion) with high relative precision (0.4 %). AMS measurements of radiocarbon are typically calibrated by reference to standard oxalic-acid ($C_2H_2O_4$) samples of known radiocativity that are derived from plant matter. Specifically, the internationally accepted absolute dating reference for so-called "modern-equivalent" radiocarbon is 95 % of the specific radioactivity in AD 1950 of the National Bureau of Standards (NBS) oxalic acid standard reference material and normalized to $\delta^{13}C_{VPDB}$ = 19 per mil [a]. With this definition, a "modern-equivalent" corresponds to 1.176(70) parts-per-trillion of ^{14}C relative to total carbon content.

As an alternative radiocarbon scale, we propose an SI-traceable method to determine ^{14}C absolute concentration which is based on linear Beer-Lambert-law absorption measurements of selected $^{14}C^{16}O_2$ ν_3-band line areas. This approach is attractive because line intensities of chosen radiocarbon dioxide transitions can be determined by *ab initio* calculations with relative uncertainties below 0.5 %. This assumption is justified by the excellent agreement between theoretical values of line intensities and measurements for stable isotopologues of CO_2 [b]. In the case of cavity ring-down spectroscopy (CRDS) measurements of $^{14}C^{16}O_2$ peak areas, we show that absolute, SI-traceable concentrations of radiocarbon can be determined through measurements of time, frequency, pressure and temperature. Notably, this approach will not require knowledge of the radiocarbon half-life and is expected to provide a stable scale that does not require an artifact standard.

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[a] M. Stuiver and H. A. Polach, *Radiocarbon* **19**, (1977) 355

[b] O. L. Polyansky et al., *Phys. Rev. Lett.* **114**, (2015) 243001